Running Head: Longitudinal Effects of Alzheimer's Disease

The Effects of Alzheimer's Disease on Expressive Language Over Time

A Senior Honors Thesis

Presented in Partial Fulfillment of the Requirements for graduation
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by

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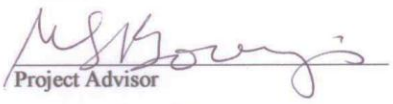
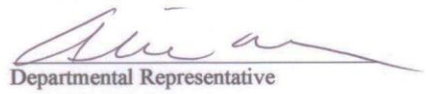
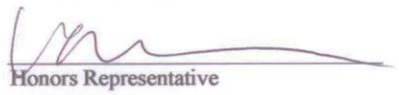
Michelle S Bourgeois Project Advisor	 Project Advisor
Allison Bean Departmental Representative	 Departmental Representative
LAURA WAGNER Honors Representative	 Honors Representative

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ABSTRACT

Individuals diagnosed with Alzheimer's disease experience cognitive impairments that cause a gradual decline of expressive language. The lack of content words such as verbs and nouns, word finding difficulty, and an over usage of pronouns characterizes the speech of individuals with Alzheimer's disease. The purpose of this study was to examine the language of patients with dementia and to document how specific features of their language declined over a certain period of time. Language samples elicited by asking participants to describe the Boston Cookie Theft picture had been previously collected at the University of Pittsburgh's Alzheimer's disease Research Center (ADRC) over the past twenty years. Audio recordings of these samples have been transcribed and stored in a data bank, called the DementiaBank at Carnegie Mellon University, Pittsburgh, PA. Six participants were selected from this data bank based on having a minimum of 3 repeat visits during which they described the picture. The transcripts of these samples were analyzed with the CLAN program in order to describe changes in specific features such as content units and pronouns over time. The results of this analysis show changes in language within the specific areas mentioned. Clinicians will be able to use these results to design training programs for caregivers to learn specific strategies for maintaining communication with persons with dementia as they move through the stages of their dementia.

INTRODUCTION

Alzheimer's disease is a degenerative disorder that affects an individual's cognitive functions, including expressive language, over a prolonged period of time (Giles, Patterson, Hodges, 1996). Specific areas of expressive language include nouns, verbs, content units, sentence completion, repetitions, and more. Previous research has explored how each of these types of language change over time as the disease gets worse (Kempler, Marquis, & Thompson, 2001). However, by looking at how these changes affect an individual's language abilities over time, clinicians may be better able to provide therapeutic services that are individualized for different people. It is important to study the specific patterns of language decline in individuals in order to help them compensate for these difficulties.

Dementia is associated with aging and linked not only to cognitive decline and memory loss, but also decreasing language skills and social skills (Bourgeois & Hickey 2009). Dementia is defined as "a syndrome characterized by acquired, persistent impairment of multiple cognitive domains – memory, language, attention, executive function, and visuospatial ability – severe enough to impair competence in daily living, occupation, and social interaction" (Grabowski & Damasio, 2004). Changes in these characteristics of the disease intrude on life's daily actions, and the tasks of everyday living become complicated not only for the person with Alzheimer's disease but also for their family members. By understanding the specific impairments of this disease, professionals and caregivers can use the information to better manage the challenging behaviors associated with dementia.

One of the most salient symptoms of Alzheimer's disease is memory loss. The degree and speed at which memory abilities decline are specific to each patient. Memory has been described as sensory memory, working memory, declarative/explicit memory, and non-declarative/implicit memory (Bourgeois & Hickey, 2009). Sensory memory is made up of two main components that are required to perceive the world, visual and auditory sensory memory (Baddeley, 1999). Information that we receive in the form of vision, hearing, taste, smell, or touch is processed and then stored as sensory memory.

Working memory, also known as short-term memory, is where information that is important for a brief period of time is stored momentarily in order to process, comprehend, act on the information, and store it for later retrieval (Baddeley, 1999). When this area of memory becomes impaired, it becomes difficult for individuals with dementia to partake in complex activities such as reasoning or comprehending (Baddeley 1999).

Long-term memory is where information is stored over time. This type of memory can be broken down into two different types: declarative/episodic (also referred to as explicit memory) and non-declarative/procedural (or implicit memory)(Baddeley, 1999). When declarative memory becomes impaired general knowledge about the world begins to become more difficult to retrieve. For example one may forget that there are 50 states in the United States of America. Forgetting words and the names of familiar people are also frequent problems associated with declarative memory. An example of episodic memory would be remembering an appointment that you attended a few days ago. These types of memory retrieval problems become troublesome for persons with dementia.

As the disease progresses, and as this type of memory deteriorates, difficulty exchanging information with their caregivers disrupts daily conversations. Procedural (or implicit) memory is associated with skills and habits acquired over one's life, such as walking, eating, and playing the piano, and are usually less impaired in the early stages of dementia. As the disease progresses, however, implicit memory can deteriorate too; forgetting how to walk, get dressed, or manage independently in the bathroom are examples (Baddeley, 1999).

Once memory becomes compromised because of the disease, age, or a combination of both, other cognitive abilities will be affected as well, such as a person's expressive language. For example, difficulty with word finding and not being able to retrieve the desired word after a short time period is a result of the decline of declarative/explicit memory in individuals with dementia (Bourgeois & Hickey, 2009). When this impairment begins to appear in the individual's speech it can become frustrating for the person with dementia and the family member trying to understand him or her. By examining the precise patterns of declining language clinicians can provide more effective word finding strategies for individuals with dementia in order to help them feel more confident while speaking.

As cognitive abilities decline, language quality changes. Research has shown that well-constructed sentences filled with ample information and vivid descriptions fade to what is often known as "empty speech" (Almor, Kempler, MacDonald, Anderson, & Tyler, 1999). A lower ratio of propositions to words, the overuse of indefinite words such as 'thing' or 'it', and the overuse of pronouns are all characteristics of the empty speech produced by people with dementia (Almor, Kempler, MacDonald, Anderson, &

Tyler, 1999). Research has shown that there is a gradual decline of both nouns and verbs within speech samples of dementia patients (Almor, Aronoff, & MacDonald, 2009). At the same time, pronouns become overused. Content units, a group of information that was always expressed as a unit by normal speakers, are also shown to decrease as dementia progresses over time (Yorkston & Beukelman, 1980). This decline can be linked to the overall decline of nouns and verbs and the characteristic empty speech that is often observed.

In the early stages of Dementia, expressive language deficits such as word finding problems for places and names begin to appear. Individuals also experience trouble understanding complex conversations and abstract language because of difficulties understanding specific words. The characteristic decline of explicit and declarative memory retrieval skills contributes to each of these shortfalls. Although there are many deficits associated with the early stage of dementia, previous research has shown that pragmatics, phonology, and syntax is preserved throughout this stage. Comprehension and knowledge of concrete language also remains intact along with the preservation of nondeclarative, implicit, and sensory memory skills (Bourgeois & Hickey, 2009).

As individuals progress into the middle stage of dementia the expressive language difficulties observed in the early stage continue to increase. The pragmatic skills that were maintained in the early stage also become impaired, especially in the area of topic maintenance. The ability to communicate with content rich sentences becomes difficult as the expressive language diminishes, which causes the conversations of these individuals to become rather empty and lacking details. The quality of receptive language also continues to decline as it becomes more difficult to grasp complex instructions and tasks

asked of them. However, just as in the early stage of dementia, phonology and syntax remain intact as well as implicit, sensory, and non-declarative memory skills (Bourgeois, 2009).

During the late stages of Dementia, very few language skills remain intact. The inability to express needs and wants often leads to the misuse of verbal or vocal productions. For example, if an individual needs help preparing dinner they may not be able to formulate the correct phrase to express their needs and instead says "help, help, help, help." Also, severe memory deficits can be seen across all language domains during this stage. Eventually, all language skills are lost and mutism occurs at the end stages of this disease (Bourgeois, 2009).

It is important to document the changes in language over time in individuals with dementia. In order to plan appropriate therapeutic services for this population, it is crucial that clinicians investigate if their clients are following the expected pattern of language decline. However this process can be time consuming for both parties, so it would be beneficial to determine if the use of a computerized language analysis (CLAN) would make this assessment process more time efficient. Therefore, in order to decide if CLAN would be helpful to clinicians this study was designed to analyze the CLAN results to see if the expected patterns of language decline are shown. It is hypothesized that the total number or words within each language sample will increase and the type-token ratio for every word will decrease over time due to the characteristic repetitive language behavior seen in individuals with dementia (Bourgeois & Hickey, 2009). It is also predicted that the number of both single word and multiword content units within each language sample will decrease over time. This is because as memory begins to decline, the language of

individuals with dementia becomes less descriptive and there is less meaningful content in their sentences and phrases. Therefore a gradual decline in the use of these specified words is predicted (Almor, Aronoff, Macdonald, et al., 2009). It is anticipated that the Mean Length of Utterance measured within each language sample will increase over time due to the increased number of words commonly observed among persons with dementia. The number of nouns, verbs, and adjectives within each language sample are hypothesized to decrease over time, while the number of pronouns within each language sample is predicted to increase over time. This can be expected due to the semantic impairments common to individuals with Alzheimer's disease (Almor et al., 2009).

METHODS

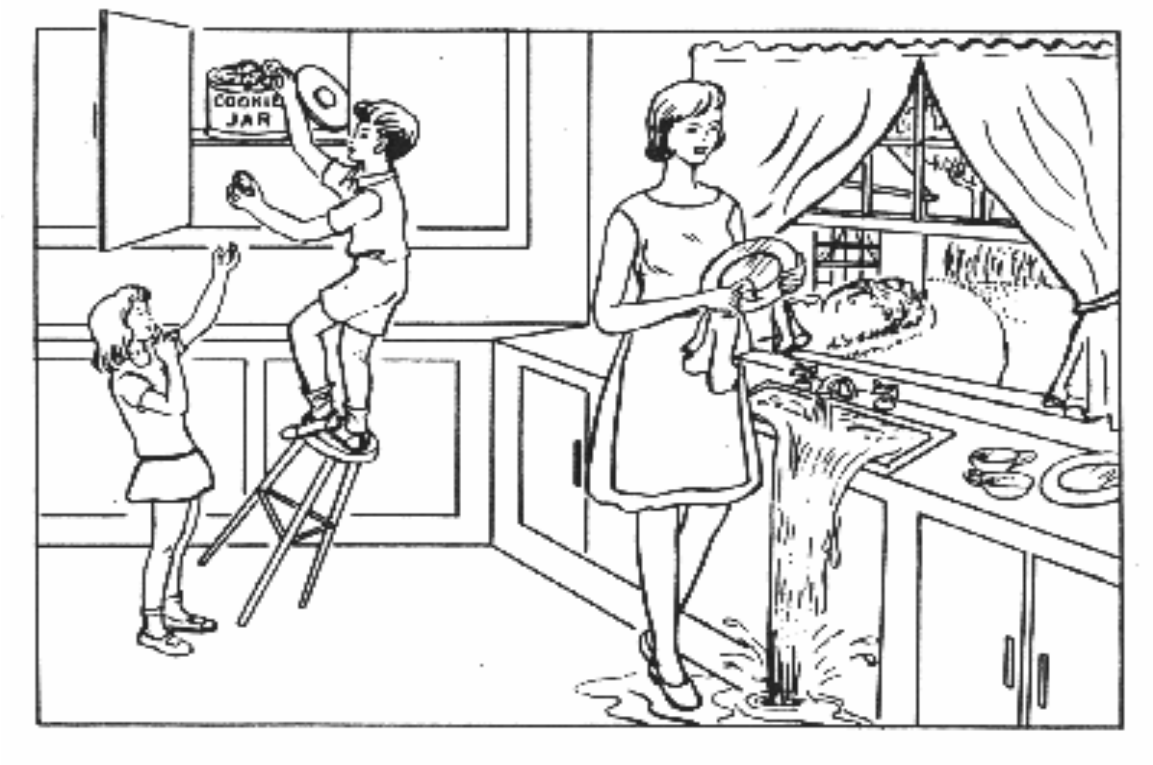
Primary Data

All the needed data was collected at the University of Pittsburgh's Alzheimer's Disease Research Center (ADRC) over the past twenty-five years. Approximately 500 people with dementia participated in studies at the ADRC that involved monitoring their cognitive decline. As a result there are audio recordings of test batteries that they took at each annual visit. These tapes have been transcribed and stored in a data bank, called the DementiaBank at Carnegie Mellon University, Pittsburgh, PA.

These language samples have been previously transcribed using the CHAT program (MacWhinney, 2000), which examines specific language features of each language sample. Individuals who volunteered in the research lab at The Ohio State University were responsible for completing this process before the current study began. This process included utilizing Adobe Audition Software in order to extract the specific sample of language from the tape recording of the entire assessment session. The samples

extracted were recordings of the *Cookie Theft Picture* description task (Goodglass & Kaplan, 1983). Figure 1 shows the Cookie Theft Picture.

Figure 1.
Cookie Theft Picture



After the files were extracted, they were then coded with CHAT software and checked for transcription errors. Figure 2 is a sample transcript of the recorded language samples.

Figure 2.
Sample Transcript

@Begin
@Languages: eng
@Participants: PAR 212-0-216v-0 Participant, INV Investigator
@ID: eng|UPMC|PAR|80;|male|MCI|212-0-216v-0|Participant|29|
@ID: eng|UPMC|INV||||212-0-216v-0|Investigator||
@Media: 212-0-216v-0, audio
***INV:** okay there it is .
***PAR:** reaching for cookies from a stool . [+ gram]
***PAR:** the stool is falling .
***PAR:** the girl's reachin(g) up .
***PAR:** <he has cookie no> [//] he has something in his hand &uh whether it's a cookie or +...
***PAR:** the lid's off the cookie jar .
***PAR:** the doors to cupboard are open . [+ gram]
***PAR:** the woman is doin(g) dishes .
***PAR:** the curtains are spread .
***PAR:** I see trees in background and along there's path plus some bushes and some other +...
***PAR:** there's a dish, two cups each one [/] one <facin(g) different> [//] the handle facin(g) different way . [+ gram]
***PAR:** the water's runnin(g) out o(f) the sink splashing on her foot is in the water . [+ gram]

Table 1 lists the types of CHAT codes used to code the transcripts. The transcript files were then sent to researchers at Carnegie Mellon University in order to check for reliability. After this process was finished, the transcript files were ready to be analyzed using specific CLAN programs for this project.

Table 1.
CHAT Codes

Code	**Meaning**
(…)	Long pauses
&	Word fragments and filters
xxx	Unintelligible Speech
+//	Self-Interruption
[: text]	Replacement
[//]	Retracing

The CLAN program consists of 24 programs for describing specific language features. Table 2 shows a listing of each of these programs.

Table 2.
CLAN Programs

Program	Function
CHAINS	Tracks sequences of interactional codes across speakers
CHECK	Verifies the correct use of CHAT format
CHIP	Examines parent-child repetition and expansion
COMBO	Searches for complex string patterns
COOCUR	Examines patterns of co-occurrence between words
DIST	Examines patterns of separation between speech act codes
DSS	Computes the Developmental Sentence Score
FREQMERG	Combines the outputs of various runs of FREQ
FREQPOS	Tracks the frequencies in various utterance positions
GEM	Finds areas of text that were marked with GEM markers
GEMFREQ	Computes frequencies for words inside GEM markers
GEMLIST	List the pattern of GEM markers in a file or files
KEYMAP	Lists the frequencies of codes that follow a target code
KW AL	Searches for word patterns and prints the line
MAXWD	Finds the longest words in a file
MLT	Computes the mean length of turn
MLU	Computes the mean length of utterance
MODREP	Matches the child's phonology to the parental model
MORTABLE	Create a frequency table of parts of speech and affixes
RELY	Measures reliability across two transcriptions
SCRIPT	Compares transcripts to target scripts
TIMEDUR	Computes time durations of utterances and pauses
VOCD	Computes the VOCD lexical diversity measure
WDLEN	Computes the length of utterances in words

Each individual program in CLAN had a specific command attached in order to analyze either the participant's language or the language of the investigator who administered the test battery. For this study, only the participant's language was analyzed. The "*PAR" command identified the utterances of the participants; the "*INV" command identified the investigator's utterances that were not included in the data analysis. After the transcript coding was determined to be reliable, the transcripts were analyzed with a selection of the CLAN Commands. Table 3 exhibits the name and command descriptor for each CLAN Command of interest for this study.

Table 3.
CLAN Commands

FREQ (every word & type-token ratio): freq +t*PAR +d2 *.cha
FREQ (single word content units): freq +d2 +s@single.cut +t*PAR *.cha
FREQ (multi word content units): freq +d2 +t*PAR +s@mult.cut +r6 +c3 *.cha
MLU: mlu +d +t*PAR *.cha
MORTABLE: mortable +t*PAR *.cha

The first CLAN program run was the FREQ program, which stands for frequency, as it analyzes selected files for the number of times each word occurs within the specified transcripts. This program provides a list of words used by the participant, and a type-token ratio, which is calculated by dividing the total number of unique words – which is called the 'type', by the total number of words used by a specified speaker – which is called the 'token' (MacWhinney, 2000).

Within the FREQ program, various commands can be attached to the initial command in order to analyze specific items, such as content units. A list of all the single-word content units, and a list of the multiword content units were stored in an electronic folder. This electronic folder was then included within the specific CLAN command in order to search for the specified single word content units within the participants' transcripts. The same process was completed for analysis of the multi-word content units. Once this was done the specific commands were entered and analysis results were sent to a folder and recorded in a spreadsheet.

The next CLAN program used for this study was the MLU program, which stands for mean length utterance in words (MacWhinney, 2000). The MLU program calculates

the ratio of morphemes to utterances for each selected file, and also for each selected speaker. The results were computed by the program and recorded in a spreadsheet.

In order to analyze specific parts of language of each participant, the MORTABLE command was selected. This command generates lists of particular parts of speech shown in Table 4. Once the results were computed by the program and recorded in a spreadsheet, the parts of speech were organized into categories of nouns, pronouns, verbs, adjectives and other for further analysis.

Table 4.
MORTABLE Parts of Speech

NOUNS	**PRONOUNS**	**VERBS**	**ADJECTIVES**	**OTHER**
-Nouns	-Pronouns	-Verbs	-Adjectives	-Wh-Words
-Regular Plural	-Possessive	-Adverbs	-Complements	-Conjunctions
-Irregular Plural	-Reflexive	-Infinitives	-Quantifiers	-Determiners
-Possessive		-Auxiliaries	-Comparatives	-Negations
		-Modals	-Superlatives	-Prepositions
		-3rd person singular irregular & regular		
		- Past Irregular & Regular		
		-Past participle irregular & regular		
		-Present Participle		

Subjects

The DementiaBank database was searched for individuals who had multiple visits and for whom three were viable transcripts for those visits. Of the 668 transcripts stored

in the database, 6 individuals had at least 3 and as many as 5 visits each, resulting in 23 transcripts.

Subject demographics for these individuals are shown in Table 5. These 6 individuals ranged in age from 64-80; 4 were male and 2 were female. Their *Mini Mental State Examination* (MMSE) (Folstein, Folstein & McHugh, 1975) scores at their initial visit ranged from 15-29 while their MMSE scores at their final visit ranged from 17-30. Three of these individuals were diagnosed with Mild Cognitive Impairment (MCI) at the first visit and they maintained that diagnosis over 3-4 years of participation in the study. One individual was initially diagnosed with Mild Cognitive Impairment but then was diagnosed as Probable Alzheimer's Disease (PAD) half way through his participation in the study. The remaining 2 participants were diagnosed as Probable Alzheimer's Disease and maintained that diagnosis throughout their participation in this study.

Table 5.
Subject Demographics

	Participant 016	Participant 120	Participant 172	Participant 212	Participant 181	Participant 213
Age at Initial Visit	67	77	73	80	78	64
Gender	Male	Male	Female	Male	Female	Male
Diagnosis	Mild Cognitive Impairment	Mild Cognitive Impairment	Mild Cognitive Impairment	Mild Cognitive Impairment /Probable Alzheimer's Disease	Probable Alzheimer's Disease	Probable Alzheimer's Disease
MMSE at Initial Visit	28	29	24	29	20	15
MMSE at Final Visit	30	29	___	19	17	___

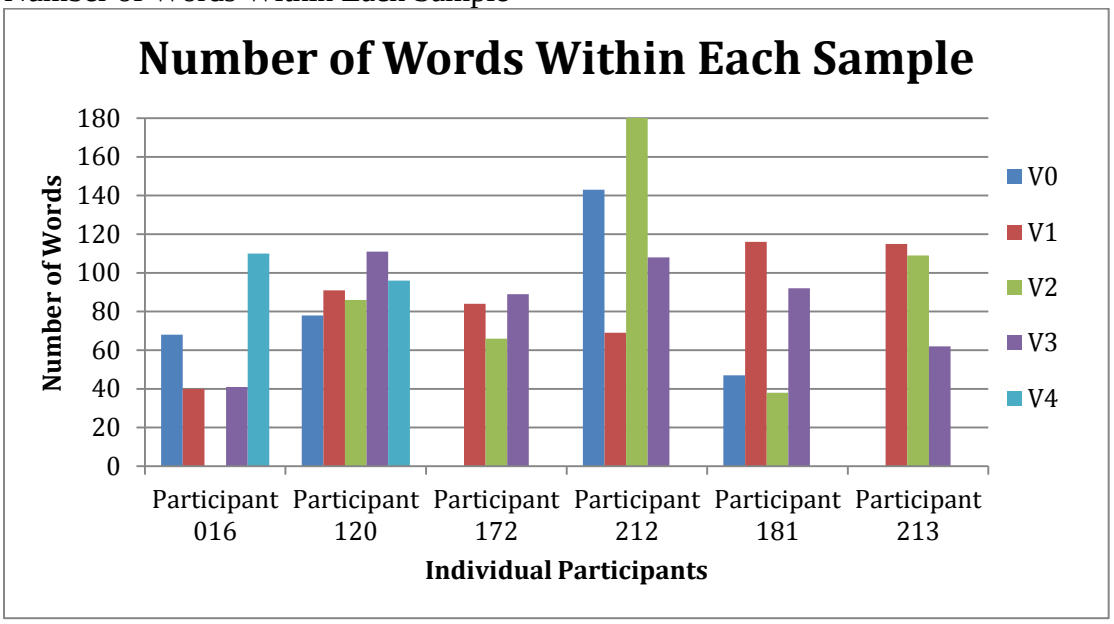
Data Analysis

The frequencies of each language category for 6 subjects were summed per year and analyzed descriptively using the Excel statistics program to show how expressive language is affected by dementia over time. Bar graphs for each language feature displayed the changes over time for each participant.

RESULTS

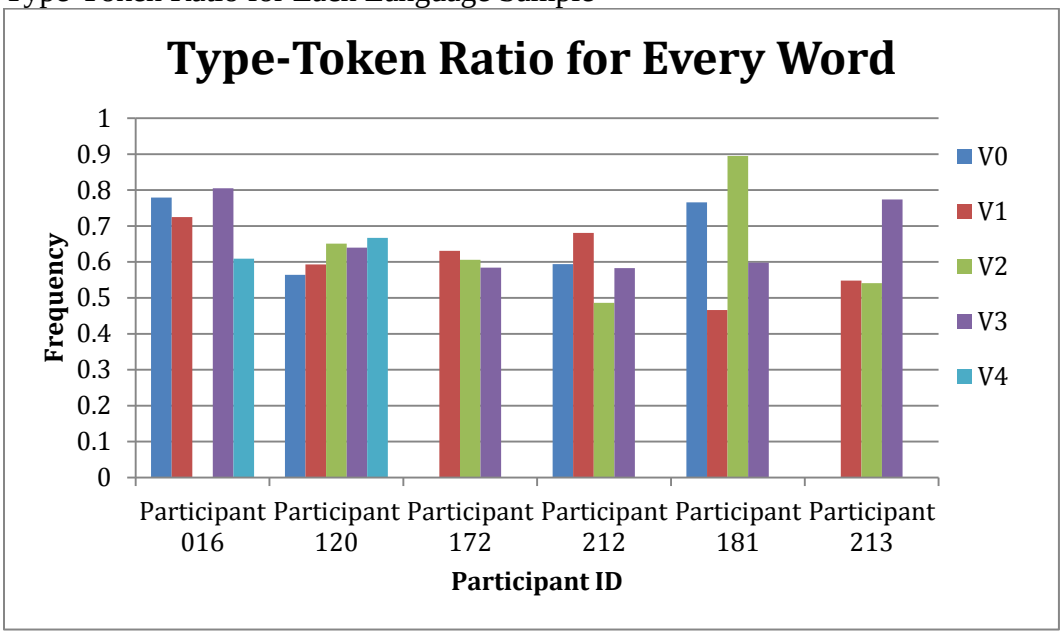
Analysis was done on the number of words within each sample in order to see if the participants used the same repetitious language typically observed in persons with dementia. Individuals with dementia often repeat themselves so it is expected that the total number of words used within each sample will increase overtime (Bourgeois & Hickey, 2009). Figure 3 shows that Participants 016, 120, and 181 increased the total number of words per sample over time, but Participants 212 and 213 used fewer words over time. Participant 172 showed no change in the number of words per sample over time. Two out of three of the participants diagnosed with mild cognitive impairment (MCI) followed the prediction (participant 016 and 120) and only 1 out of the 3 participants with probable Alzheimer's disease (PAD) followed the prediction (participant 181).

Figure 3.
Number of Words Within Each Sample



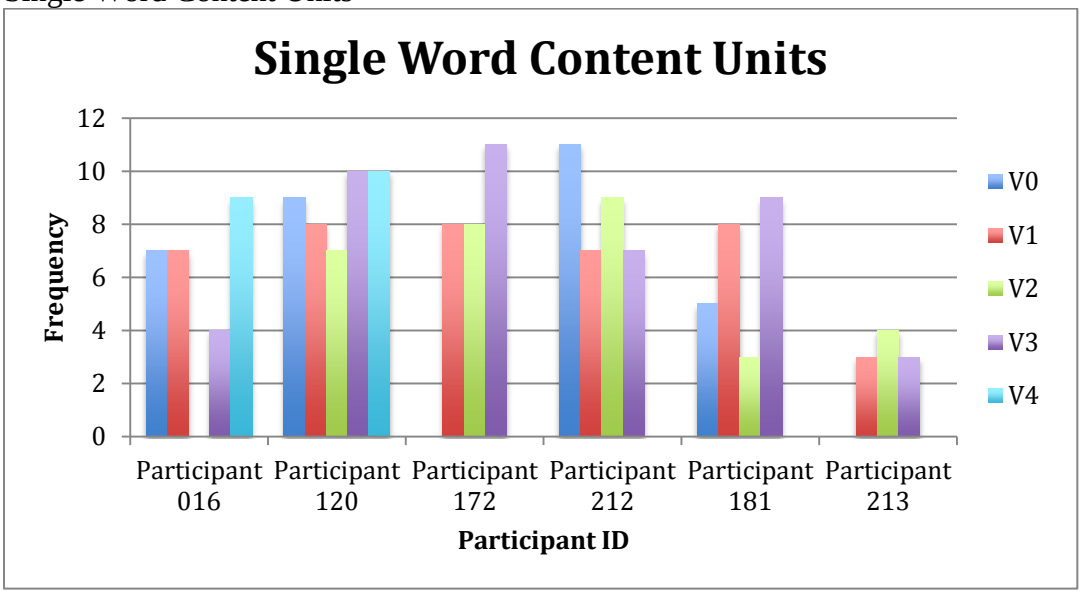
Analysis of the type-token ratio for every word was completed and it was predicted that the ratio of unique words to the total number of words per sample would decrease over time (Bourgeois & Hickey, 2009). Figure 4 shows that participants 120 and 213 increased their type-token ratio over time but participants 016, 172, and 181 decreased their type-token ratio over time. Participant 212 did not show changes in their type-token ratio over time. Two out of the 3 MCI participants followed the prediction (participant 016 and 172) and only 1 out of 3 PAD participants followed the prediction (participant 181).

Figure 4.
Type-Token Ratio for Each Language Sample



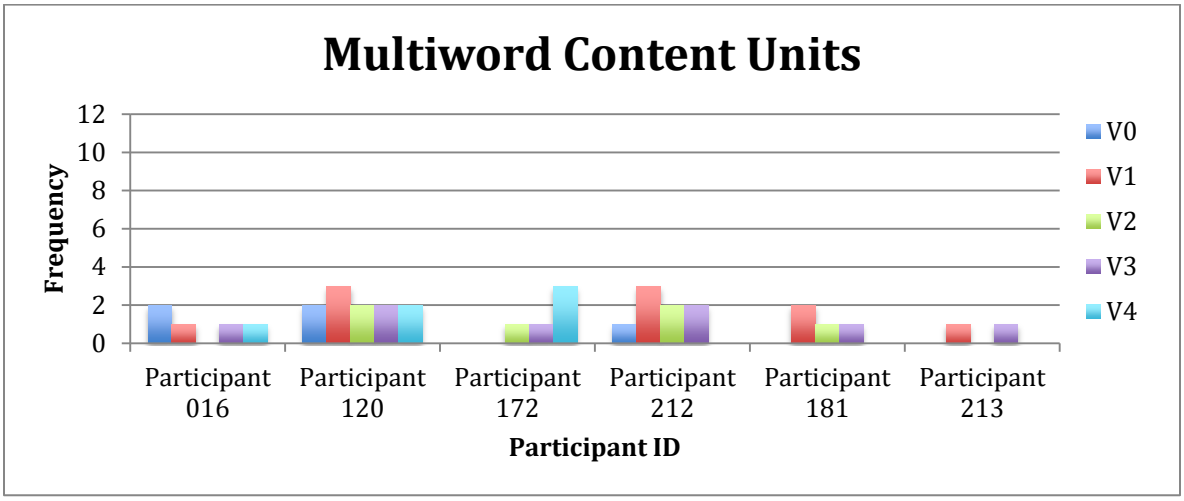
Content units were analyzed within each sample in order to document the change in informativeness over time. It was predicted that the number of content units would decrease over time. This was predicted based on the previous research that shows that as Alzheimer's disease progresses the individual's speech becomes less descriptive (Bourgeois, 2009). Figure 5 shows that participant 212 was the only individual who used a decreased amount of content units per sample over time. Participants 016, 120, 172, and 181 all increased the number of content units they used per sample over time and participant 213 showed no changes. None of the participants diagnosed with MCI followed this prediction while 1 out of 3 of the participants diagnosed with PAD followed the prediction (participant 212).

Figure 5.
Single Word Content Units



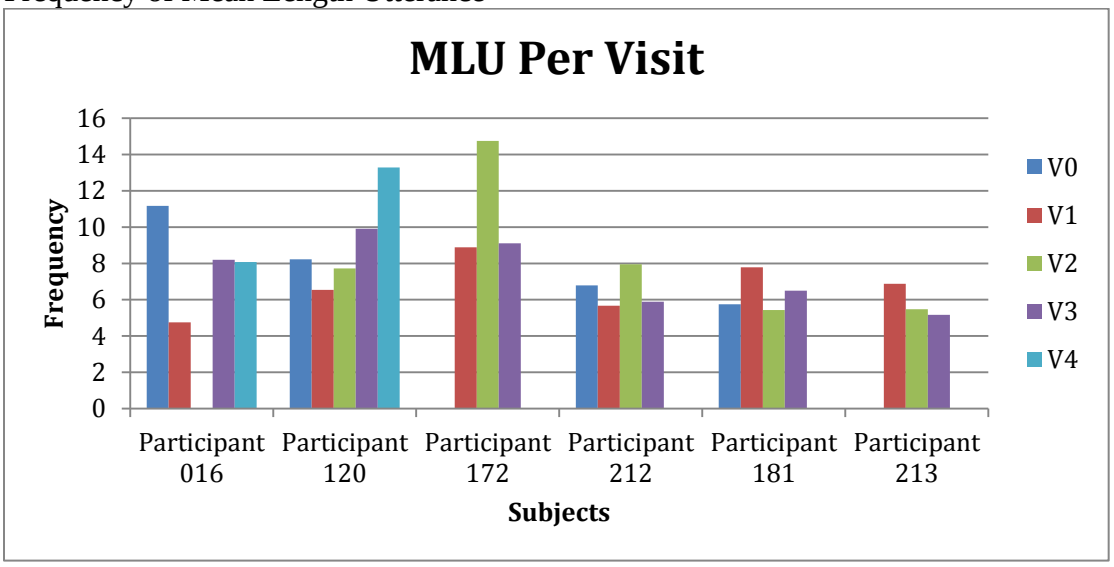
As shown in Figure 6, participants 172 and 212 increased the number of multiword content units used per sample over time and participants 016 and 181 decreased the number of multiword content units used per sample over time, following the predicted pattern of language decline of content units. Participants 120 and 213 showed no change in the number of multiword content units used per sample over time. Only one participant diagnosed with MCI followed the prediction (participant 016) and only one participant diagnosed with PAD followed the prediction (participant 212).

Figure 6.
Multiword Content Units



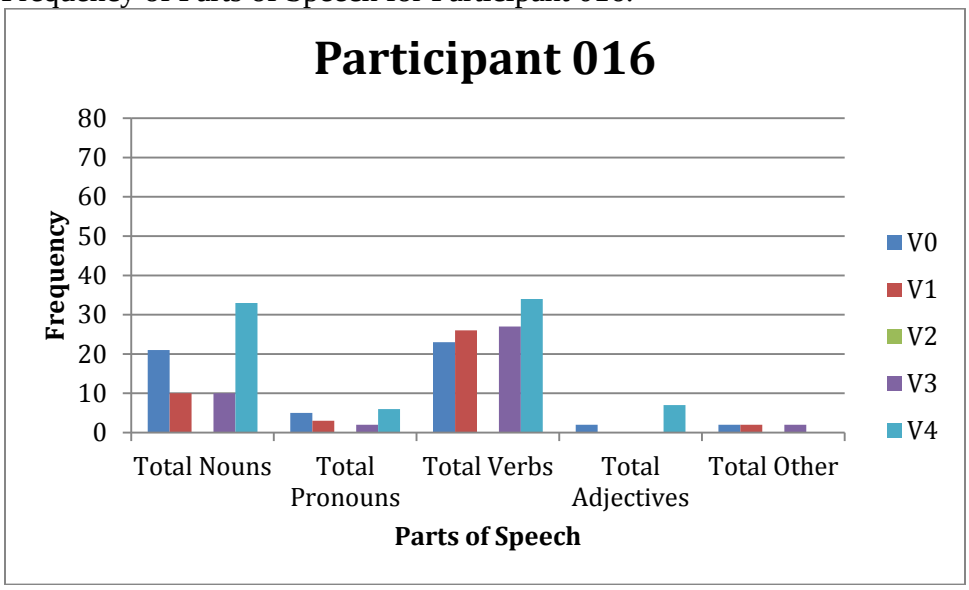
Mean length of utterance (MLU) was analyzed as a reflection of the increased use of words over time due to increased use of repetitions within their language (Bourgeois & Hickey, 2009). It was predicted that the mean length utterance would increase over time. As shown in Figure 7, participants 120 and 181 increased their MLU per sample over time and participants 016, 212 and 213 decreased their MLU per sample over time. Participant 172 showed no changes in their MLU over time. Only one of the participants diagnosed with MCI followed the prediction (participant 120) and only one of the participants diagnosed with PAD followed the prediction (participant 181).

Figure 7.
Frequency of Mean Length Utterance



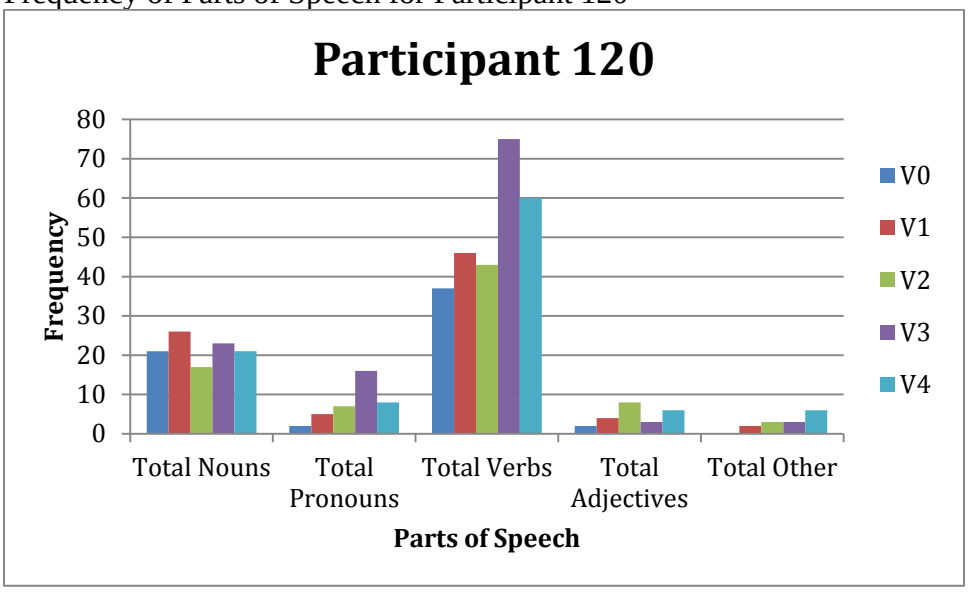
Figures 8-13 depict the individual patterns of language decline for each participant and for each language feature analyzed. When analyzing the frequency of the various parts of speech it was expected that the total number of nouns, verbs, and adjectives used over time would decrease (Almor, et.al., 1999). In contrast, the total number of pronouns used over time was predicted to increase (Almor, et. Al., 1999). As shown in Figure 8, participant 016 shows an increase in nouns, verbs, and adjectives over time, and no changes in pronouns and others (conjunctions and demonstratives). This was not the expected pattern in comparison to previous research.

Figure 8.
Frequency of Parts of Speech for Participant 016.



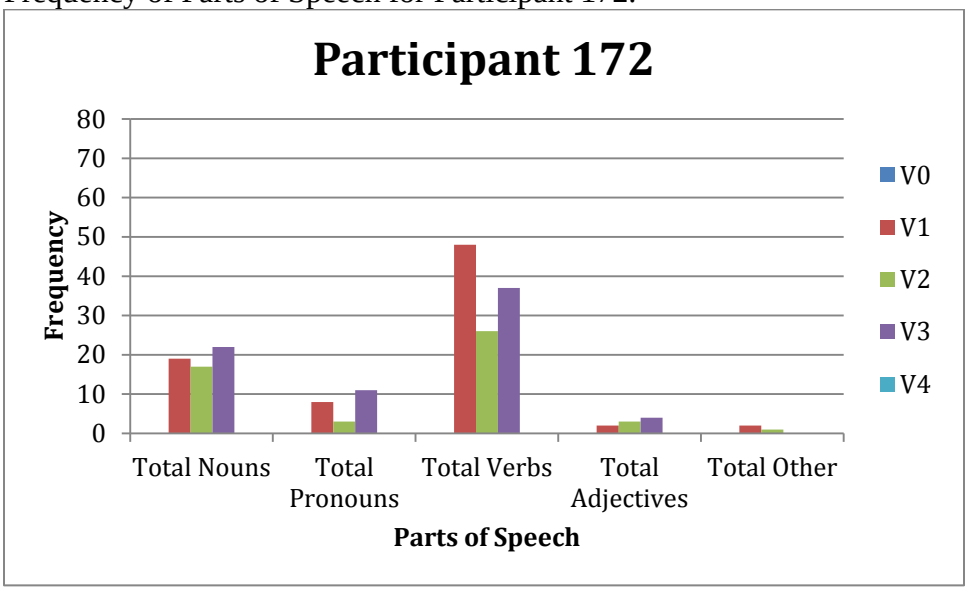
As shown in Figure 9, participant 120 shows an increase in pronouns, verbs and other (conjunctions and demonstratives, and no changes in nouns and adjectives. This was not the expected pattern in comparison to previous research.

Figure 9.
Frequency of Parts of Speech for Participant 120



As shown in Figure 10, participant 172 shows an increase in nouns, pronouns, and adjectives over time and a decrease in verbs and other (conjunctions and demonstratives). This did not follow the predicted patterns of previous research

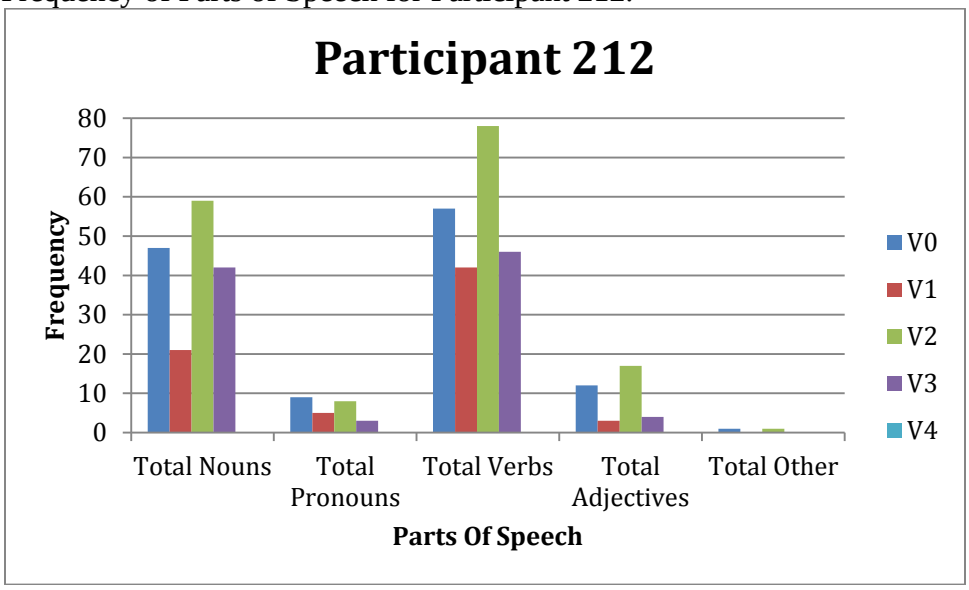
Figure 10.
Frequency of Parts of Speech for Participant 172.



Overall, participants 016, 120, and 172, who were all diagnosed with MCI followed the predictions for an increase in the number of ponouns used over time, but did not follow the predictions for a decrease in the number of nouns, verbs, and adjectives used over time.

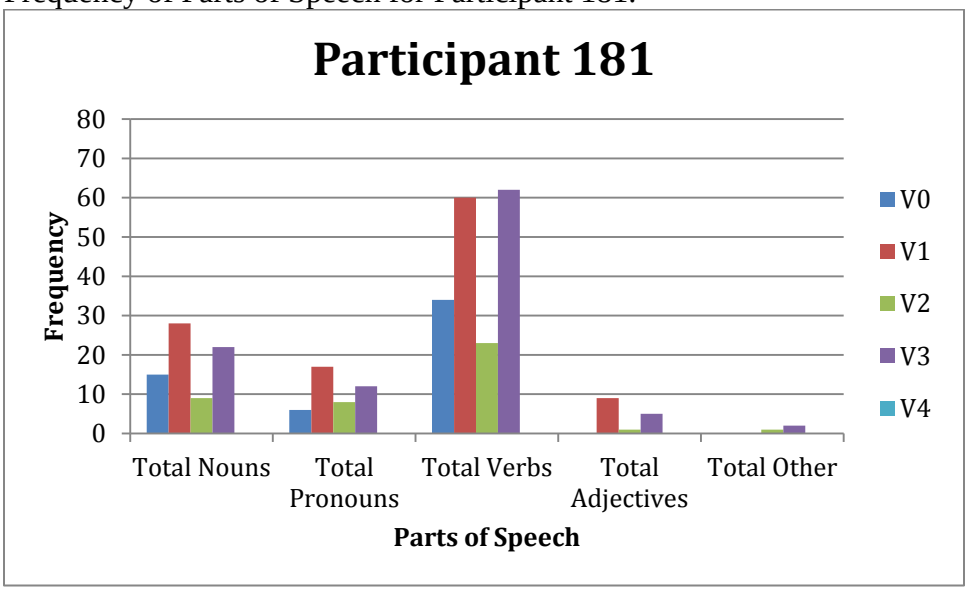
As shown in Figure 11, participant 212 show an decrease in nouns, pronouns, verbs, and adjectives over time and no significant change in other(conjunctions and demonstratives). With the exception of the decrease of pronouns, this followed the expected pattern shown in previous research.

Figure 11.
Frequency of Parts of Speech for Participant 212.



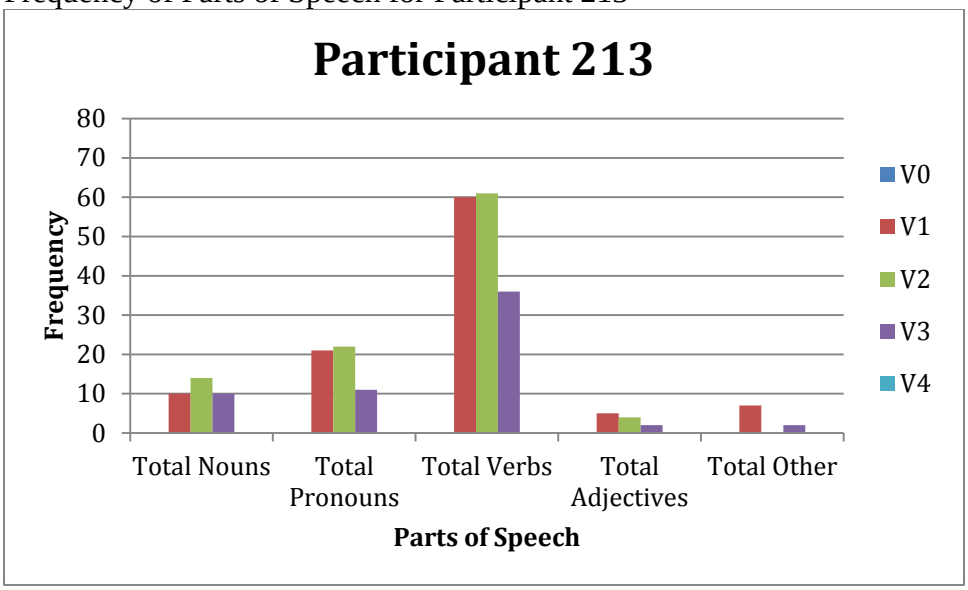
As shown in Figure 12, Participant 181 shows an increase in nouns, pronouns, verbs, and other over time, and a decrease in adjectives. This does not follow the expected pattern of language decline in comparison to previous research.

Figure 12.
Frequency of Parts of Speech for Participant 181.



As shown in Figure 13, Participant 213 shows a decrease in pronouns, verbs, adjectives and other over time and no significant change in nouns. With the exception of pronouns and nouns, this does not follow the expected pattern of language decline as shown in previous research.

Figure 13.
Frequency of Parts of Speech for Participant 213



Overall participants 212, 181, and 213, who were all diagnosed with PAD followed the predictions for a decrease in the number of verbs and adjectives used over time but did not follow the predictions for a decrease in the number of nouns used over time and an increase in the number of pronouns used over time.

DISCUSSION

The purpose of this study was to examine how the expressive language of individuals with Alzheimer's disease declined in comparison to patterns previous research has shown. Results of the analyses revealed that as a group only half of the participants increased the number of words used per sample. Two of these individuals were diagnosed with MCI and the other participant was diagnosed with PAD. Three out

of the 6 participants decreased their type token ratio per sample over time. Two of these participants were diagnosed with MCI and the other participant was diagnosed with PAD. The only participant that decreased the number of single word content units used over time was an individual who was diagnosed with PAD. Less than half of the participants, 2 out of 6 decreased the number of multiword content units used over time, one of them being diagnosed with MCI and the other with PAD. The same results were observed when analyzing the increase of mean length of utterance per sample over time. Two out of 6 participants followed the prediction, one who was diagnosed with MCI and one who was diagnosed with PAD. Only one of the participants, who was diagnosed with PAD, showed a decrease in the number of nouns used over time. Half of the participants showed an increase in the number of pronouns used over time. Two of these participants were diagnosed with MCI and the other participant was diagnosed with PAD. Half of the participants also showed a decrease in the number of verbs used over time. One of these participants was diagnosed with MCI and the other two were diagnosed with PAD. Three of the six participants, all who had diagnoses of PAD, showed a decrease in the number of adjectives used over time.

These findings suggest that the CLAN analysis of the *Cookie Theft Picture Description Task* may not be the most appropriate way to describe the language changes in individuals with Alzheimer's disease. It may be possible that this task was too simple for the participants and did not challenge their memory as much as other tasks would. Other tasks, such as a story retell task or a conversation task, might reveal changes in language skills that reflect their stage of memory impairment. These tasks may require

complex skills that would be needed for formulating words and ideas to produce a language sample that is more similar to the everyday language used by these individuals.

Limitations

One aspect of this research project that may have affected the results is that 3 of the 6 participants had the diagnosis of mild cognitive impairment throughout the testing period. Since they did not have probable Alzheimer's disease it can be expected that their language patterns were different from those individuals who have probable Alzheimer's disease.

The small sample size of this study may have also affected the results. Because there were only 6 participants studied, statistical analysis of the data was not appropriate; a sample size of 20 or more would have permitted more in depth analysis.

Another limitation of the study was the use of retrospective data. Due to the fact that the participants were chosen from pre-collected data, it was difficult to compile a large sample size that met the requirements for this study. Future studies should be planned prospectively to collect language data from well-described individuals experiencing confirmed subtypes of cognitive impairment.

Future Studies

In order to better understand the language changes in dementia, it would be interesting to do a study comparing different ways to measure expressive language, using a picture task analysis, a story retell analysis, and a conversational analysis with a larger sample size. This would allow for more accurate analysis of the deterioration of expressive language skills of individuals with Alzheimer's disease.

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